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The Vegetational Composition of the Samuel H. Ordway Memorial Prairie

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THE VEGETATIONAL COMPOSITION OF THE SAMUEL H. ORDWAY MEMORIAL PRAIRIE

BY

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OF THE

SAMUEL H. ORDWAY MEMORIAL PRAIRIE

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Date

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ABSTRACT

This thesis represents the first half of a two year study of the vegetational composition of the Samuel H. Ordway, Jr. Memorial Prairie. Quadrat and point frame sampling was completed along 100 transects distributed over the 10 pastures. Biomass for the study area was determined to be 133.3 $g \cdot m^{-2}$ for live weight and 104.0 $g \cdot m^{-2}$ for mulch. Basal cover for Ordway Prairie was found to be 12.5%. The study area was found to be predominantly occupied by warm season species. Andropogon scoparius was found to be highest in relative density while Carex was highest in relative frequency. Biomass and species composition data are listed by pasture.

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INTRODUCTION

The Samuel H. Ordway, Jr. Memorial Prairie has been designated as a model preserve of The Nature Conservancy. All management activities are designed to preserve and enhance its natural qualities. Various management tools are used to simulate the many factors which maintained the native prairie.

The objective of this study is to establish base-line data on the present vegetative composition of the area. This will provide a reference against which future changes can be determined, and the effects of various management techniques measured.

DESCRIPTION OF STUDY AREA

Samuel H. Ordway, Jr. Memorial Prairie is located approximately 9.7 km west of Leola, South Dakota in McPherson County. South Dakota Highway 10 forms its north border. The Ordway Prairie is included in parts of townships 125-126 north latitude and ranges 68-69 west longitude. The total land area amounts to 3,127 hectares or about 12 square miles.

The study area lies on the eastern edge of the Missouri Coteau, an extensive highland region approximately 121.5 km wide at the northern border of McPherson County. The coteau is bounded on the west by the Missouri River lowlands and on the east by the James River lowlands. Elevation at the study area is approximately 480 meters above sea level; the bordering lowlands are some 60 to 90 meters lower (Flint 1955).

The uppermost bedrock formation is composed of Cretaceous Pierre Shale. The only glacial sheet to cover this area was that of the Late Wisconsin stage of the Pleistocene glaciation which entered approximately 17,000 years ago. The coteau was completely covered as of 15,000 years ago with ice thickness varying from 660 to 2000 meters. The glacier ceased moving in the James Basin 11,000 years ago but remained for 5,000 years more. The ice sheet provided for a general smoothing of the

bedrock and an increase in altitude by the deposition of till material (Hertz 1976).

Three types of glacial moraines can be found within the study area: end moraines; ground moraines; and stagnation moraines. End moraines cover almost the entire study area. They are made up of till deposits left near the margin of the ice and may show a relief of 330 meters or more. A lobe of ground moraine protrudes in a southwesterly direction across the northeast corner of the area. It consists of till deposited from the advance and retreat of the ice and is characterized by irregular swells and swales. Stagnation moraines, a lobe of which runs across the southeast edge of the study area, are denoted by hilly topography composed of a mixture of boulders, sand, silt, and clay (Flint 1955).

The soil type most commonly encountered is the Vida-Williams Loam, a characteristic soil of glacial till plains. It is a fairly deep loam on uplands with 6 to 15% slope and is composed of mixed mineralogy. It is susceptible to severe wind and water erosion. Vida-Zahill loam is found in hilly uplands with a 15 to 25% slope. These deep to moderately deep loamy soils are also subject to severe erosion. Parnell silty clay is a black wetland soil characteristic of glacial depressions. Other soil types found in the study area include the Williams-

Bowbells loams and the Williams-Bowbells-Parnell complex (U.S.D.A. Soil Conservation Service 1976; U.S.D.A. 1971). Soil drainage is poor with no well defined surface drainage pattern. The study area is dotted with approximately 400 lakes or sloughes, the largest of which covers nearly 120 acres (Lokemoen et al. 1975).

The climate of Ordway Prairie is continental. The average annual temperature is 6.5°C. Temperature extremes can range from 46°C. in the summer to -43.0°C. in the winter. The coldest month is January while the warmest is July. The mean monthly temperatures for June, July, and August are 18.9°, 22.8°, and 22.1°C., respectively (Hodge 1974). For 1977 these monthly temperatures were 20.3°, 23.5°, and 18.6°C. The average annual precipitation for Leola is 41.9 cm. with mean monthly amounts of 9.9, 6.9, and 5.3 cm. for June, July, and August, respectively (Hodge 1974). These monthly amounts during 1977 were 5.3, 5.6, and 6.9 cm. (U.S. Department of Commerce 1977).

Wind velocity data are available only for Aberdeen. Winds average 17.8 km. per hour out of the south for the summer months and 19.4 km. per hour out of the northwest during the winter months. Wind velocity during storms occasionally reaches 81 km. per hour (Spuhler 1966).

The Ordway Prairie is located in an area classified by Kuechler (1964) as an Agropyron-Stipa association.

He described it as a moderately dense, short or medium tall grassland. The dominant plants are Agropyron smithii,[1] Bouteloua gracilis, Stipa comata, and Stipa viridula. Other major species include Andropogon scoparius, Andropogon gerardii, Poa pratensis, Calamovilfa longifolia, Ambrosia artemisiifolia, Aster ericoides, Artemisia ludoviciana, Helianthus maximiliana, Psoralea argophylla, Carex spp., Echinacea pallida, Solidago spp., and Lotus purshianus. A comprehensive herbarium for Ordway Pairie has been established and described by Hertz (1976).

The study area now known as Sanuel H. Ordway, Jr. Memorial Prairie was purchased by The Nature Conservancy on July 10, 1975. Nature Conservancy is a nonprofit national organization which acquires tracts of ecologically and environmentally significant land for preservation and for educational and scientific study. The land was purchased from Leroy Hoffman who had been using a rest-rotation grazing system. Generally, this involved heavy grazing for part of the year and then resting for a full season in an attempt to simulate the grazing effects of the native herbivores, specifically insects, rodents, lagomorphs, antelope and bison (Lokemoen 1975). This

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[1] Scientific names follow Van Bruggen (1976).

was carried on for 5 or 6 years, the length of time that Hoffman owned the land.

Prior to Hoffman, the land was owned by Tom Boyland. During his 20 year ownership, he also attempted to re-establish some of the native plant species. He used a combination of resting, then reseeding to Stipa viridula and resting again up to two years. All of the rangeland was rested once every five years and from 1250 to 1750 hectares were completely deferred each year. Boyland also used stock-watering ponds and cross-fencing to improve the range. The range condition and the carrying capacity for his cattle did improve as noted by Stensland (1960) and Pozarnsky (1966).

In the spring of 1976, Paul Bultsma was hired by the midwest regional branch of The Nature Conservancy as a permanent manager of Ordway Prairie. He has the main responsibility for maintenance, improvement, management, and the development of future research guidelines.

PROCEDURE OF THE STUDY

Selection of Sampling Locations

Permanent representative transect sites were subjectively selected in the field so as to sample consistent upland sites and to cover the various soil types within each pasture. A soils map (U.S.D.A. Soil Conservation Service 1976) of Ordway Prairie was used to determine tentative transect distributions. Figure 1 shows the transect distribution and Table 1 provides the transect totals by pasture. Table 1 also provides the numerical codes assigned to the pastures for ease of recording.

Methods of Sampling

Future replication of transect sites was insured by marking the site with ear tags and by a portable right triangle transect. The numbered ear tags were attached to fence lines to mark and identify the sample sites. Locations were then recorded in field notes. The transect consisted of a lightweight chain laid out at a right angle to the tagged fence. The right angle was established by means of a right triangle attached to one end of the chain. The transect was marked every 20 feet for quadrat and point frame sampling. The first sampling site was standardized at 50 feet from the fence to avoid border disturbance (Fig. 2). Quadrat sampling was used to

Figure 1
ORDWAY PRAIRIE
TRANSECT DISTRIBUTION

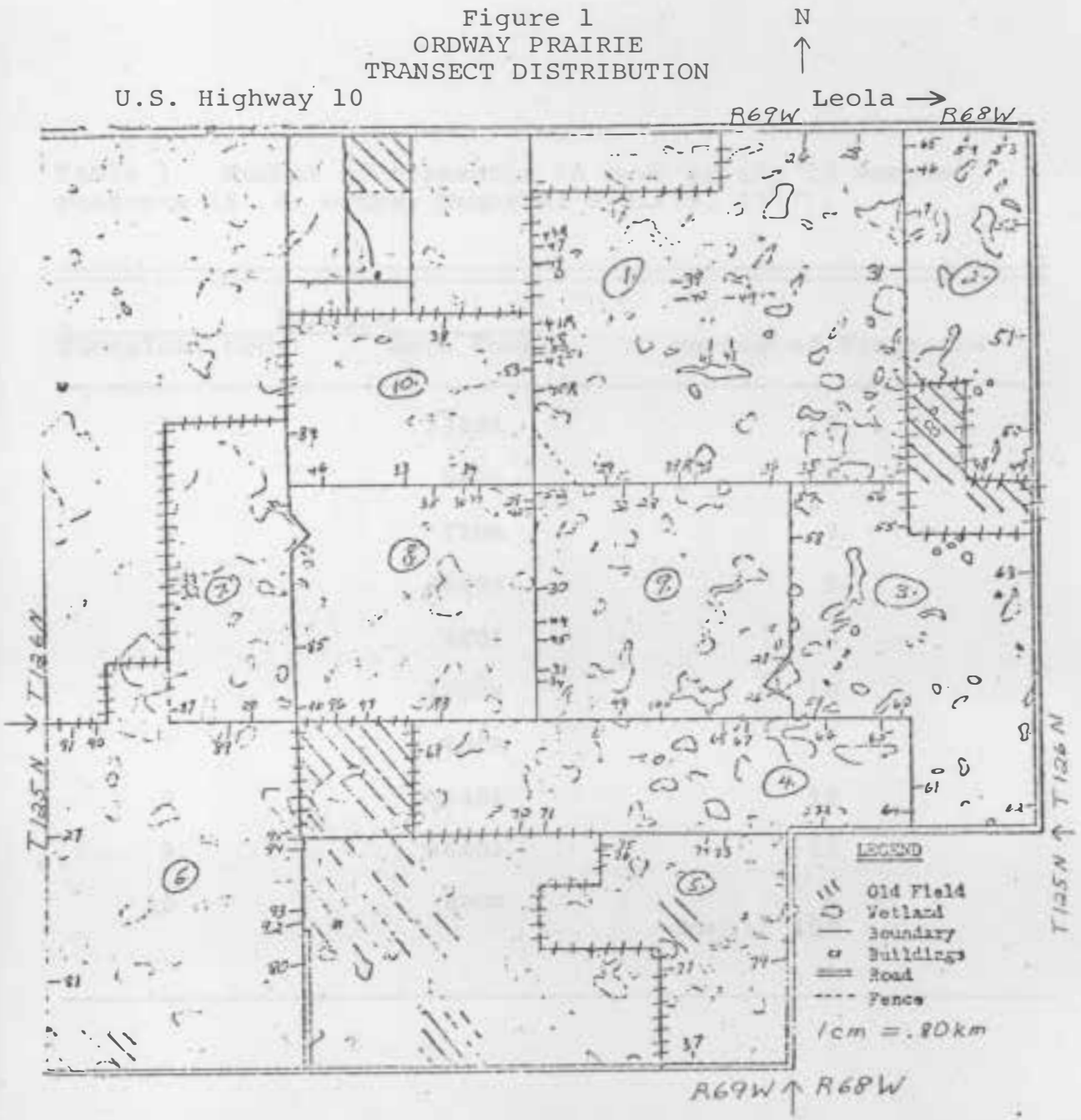

Table 1. Number of transects in each of the 10 sampled pastures (S. H. Ordway Memorial Prairie, 1977).

Pasture		
Numerical Code	Acre Code	Number of Transects
1	1320A	22
2	560A	10
3	720A	9
4	S640A	9
5	440A	7
6	1000A	10
7	400A	5
8	W640A	10
9	E640A	12
10	480A	6
	Total	100

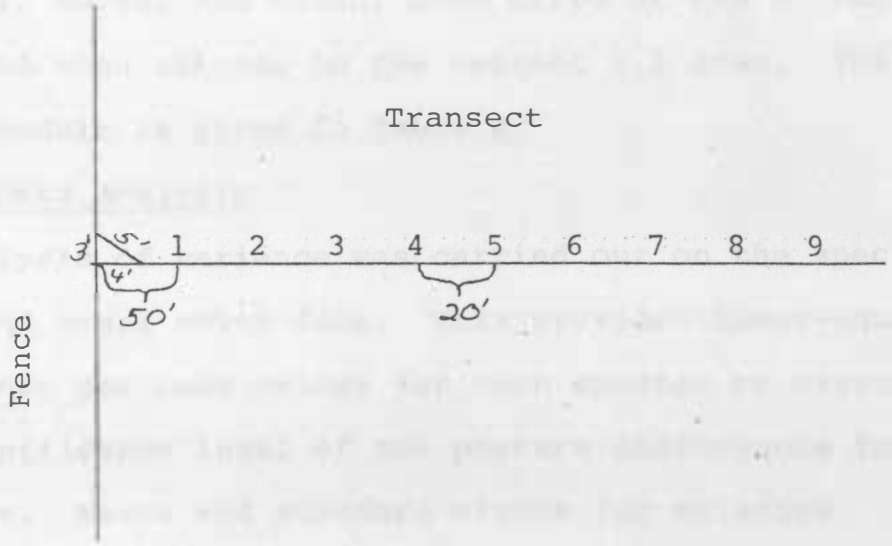

Figure 2. Sketch of transect chain showing right triangle at fence line, quadrat sampling sites along the transect, and distance between each sampling site (S. H. Ordway Memorial Prairie, 1977).

determine species frequency and biomass; point frame sampling was used to determine species density and per cent basal cover. The size of the quadrat was 0.1 square meter.

Productivity sampling consisted of clipping the quadrats at a height of 0.5 and 1.0 mm. Clippings were separated into grasses, forbs, and mulch, oven dried at 109°C. for 24 hours, and then weighed to the nearest 0.1 gram. The sampling schedule is given in Table 2.

Methods of Data Analysis

An analysis of variance was carried out on the species frequency and basal cover data. This provided least-squares mean frequency per cent values for each species by pasture and the significance level of the pasture differences for each species. Means and standard errors for relative density of the species were also calculated by pasture. These data were used to compute pasture similarity coefficients according to Cox (1967). The basal cover analysis provided least-squares mean per cent basal cover for each pasture as well as the significance level of the pasture differences.

Analysis was also carried out on the productivity data. This provided least-squares mean weights for grasses, forbs, and mulch in each pasture and the significance level of the pasture differences.

Table 2. Sampling schedule for S. H. Ordway Memorial Prairie, 1977.

Date	Sample
June 21, 1977 - July 1, 1977	Selecting and numbering of transect sites in all pastures.
July 4, 1977 - July 13, 1977	Species composition (quadrat and point frame) of all transects.
July 25, 1977 - August 3, 1977	Productivity sampling of all transects.
August 21, 1977 - August 28, 1977	Species composition (quadrat and point frame) of all transects.

RESULTS AND OBSERVATIONS

The present investigation is the first such study ever conducted at Ordway Prairie. Data comparisons with other mixed-grass prairies are made in order to provide comparisons of similar grassland systems.

Productivity

The productivity is summarized in Table 3. The pasture conditions are those given by Hutcheson (1977) and Lewis (1976). Pastures were rated from Good-Excellent (G-E) to Fair (F) based on a brief surveillance of the area. The conditions are an indication of the per cent of climax vegetation: 25 to 50% is considered Fair; 50 to 75% is Good; and 75 to 100% is Excellent (Stoddart and Smith 1955). The least-squares mean weight (weighted mean) of live biomass in this study was 133.3 $g \cdot m^{-2}$. Lauenroth and Whitman (1977) reported 256 $g \cdot m^{-2}$ for a study area in southwestern North Dakota that had been ungrazed for 14 years and was dominated by Stipa comata and Agropyron smithii. Lauenroth et al. (1975) reported live biomass at 105 $g \cdot m^{-2}$ for five northern mixed prairie grasslands in southeastern Montana. Redmann (1975) reported total live biomass for 2 years in a Stipa comata dominated western North Dakota grassland as 116 and 168 $g \cdot m^{-2}$. Ode and Tieszen (1978) reported 121.0 $g \cdot m^{-2}$ for portions of Ordway Prairie. Dodd et al. (1971) found 98.9 $g \cdot m^{-2}$ (low

Table 3. Least-squares mean weights (g/m^2) of grass, forbs, and mulch in the upland communities of 10 pastures of S. H. Ordway Memorial Prairie, 1977.

Pasture Code	Pasture Condition*	Grazing Practice 1976	Grazing Practice 1977	Grass	Forbs	Mulch
1	G	Rest	April 27 - Sept. 27	111.6 ± 6.0	27.7±2.3	133.6±14.8
2	F+	Rest	April 15 - June 1	97.1 ± 8.9	30.8±3.4	154.9±21.9
3	G-	May 15-Oct. 15	Rest	120.1 ± 9.4	50.9±3.5	129.1±23.1
4	F+	Rest	April 15 - June 15	87.4 ± 9.4	39.9±3.5	87.3±23.1
5	F	Rest	April 15 - June 15	68.8 ±10.6	41.1±4.1	38.8±26.2
6	G	Rest	Rest	101.4 ± 8.9	33.3±3.4	67.7±21.9
7	G	Rest	Rest	119.6 ±12.6	29.0±4.7	112.8±31.0
8	G	Rest	Rest	126.0 ± 8.9	32.2±3.4	114.7±21.9
9	G-E	Rest	April 15 - June 1	75.8 ± 8.1	27.4±4.3	151.0±28.3
10	F+	May 15 - Oct. 15	Rest	84.7 ±11.5	28.0±4.3	50.0±20.0
$\bar{x}$				99.3 ± 3.0	34.0±1.1	104.0± 7.5

* G = Good, F = Fair, E = Excellent

range condition) and 149.6 $g \cdot m^{-2}$ (high range condition) in a western South Dakota mixed-grass prairie.

The least-squares mean weight of forbs in this study was 34.0 $g \cdot m^{-2}$. Lauenroth et al. (1975) found forb biomass to be 35 $g \cdot m^{-2}$ for five southeastern Montana grasslands. Redmann (1975) reported 35 $g \cdot m^{-2}$ for a Stipa comata dominated community in western North Dakota.

The least-squares mean weight of mulch at Ordway Prairie was 104.0 $g \cdot m^{-2}$. Dodd et al. (1975) reported 52.0 $g \cdot m^{-2}$ (low range condition) and 136.1 $g \cdot m^{-2}$ (high range condition) for a western South Dakota mixed-grass prairie. Ode and Tieszen (1978) found 154.4 $g \cdot m^{-2}$ for parts of Ordway Prairie. All data from the cited studies were taken sometime between July 20 and July 30 which corresponds to the July 25 to August 3 sampling dates of the present study.

Figure 3 shows the biomass and mulch weights for the 10 pastures in Ordway Prairie. Pasture 3 had the highest live weight (171.0 $g \cdot m^{-2}$) while Pasture 9 had the lowest (103.2 $g \cdot m^{-2}$). Pasture 3 was rated Good and Pasture 9 was rate Good-Excellent. However, Pasture 9 was grazed during the spring of 1977 and Pasture 3 was not. Pastures 2, 4, 5, 9, and 10 had biomass weights below the total mean of 133.3 $g \cdot m^{-2}$. They were all low rated pastures except for Pasture 9 which was spring grazed.

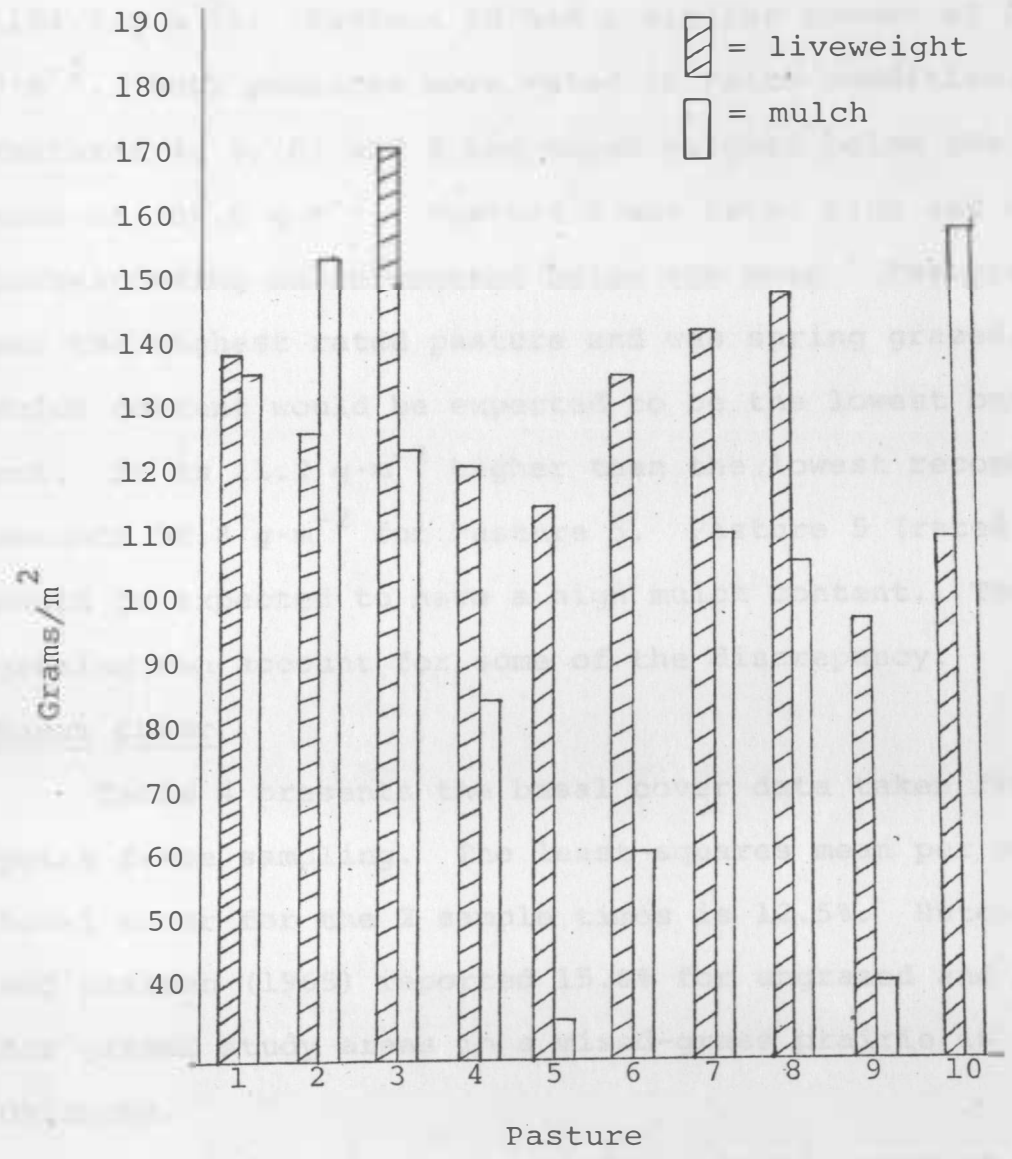

Figure 3. Productivity expressed in grams/m^2 for the 10 sampled pastures of S. H. Ordway Memorial Prairie, 1977. Significance level of pasture differences for liveweight and mulch = .005.

Pasture 2 contained the highest amount of mulch (154.9 $g \cdot m^{-2}$). Pasture 10 had a similar amount of 151.0 $g \cdot m^{-2}$. Both pastures were rated in Fair+ condition. Pastures 4, 5, 6, and 9 had mulch weights below the total mean of 104.0 $g \cdot m^{-2}$. Pasture 6 was rated high and had a corresponding mulch content below the mean. Pasture 9 was the highest rated pasture and was spring grazed. Its mulch content would be expected to be the lowest but it is not. It is 11.2 $g \cdot m^{-2}$ higher than the lowest recorded amount; 38.8 $g \cdot m^{-2}$ for Pasture 5. Pasture 5 (rated Fair) would be expected to have a high mulch content. The spring grazing can account for some of the discrepancy.

Basal Cover

Table 4 presents the basal cover data taken from point frame sampling. The least-squares mean per cent basal cover for the 2 sample times is 12.5%. Hutcheson and Baalman (1965) reported 15.0% for ungrazed and 13.5% for grazed study areas in a mixed-grass prairie in Oklahoma.

Figure 4 presents the per cent basal cover of the 10 sampled pastures. The maximum value for basal cover was found in Pasture 8 (15.6%). This pasture was rated high (Good) and had been rested the last 2 years. The lowest value was in Pasture 4 (10.7%) which was rated low

Table 4. Least-squares mean per cent basal cover in the upland communities of 10 pastures of S. H. Ordway Memorial Prairie, 1977.

Pasture Code	Pasture Condition	Grazing Practice 1976	Grazing Practice 1977	Basal Cover (%) and Standard Error
1	G	Rest	April 27 - September 27	11.5 ± 0.4
2	F+	Rest	April 15 - June 1	12.1 ± 0.5
3	G-	May 15 - Oct. 15	Rest	12.3 ± 0.6
4	F+	Rest	May 15 - October 15	10.7 ± 0.6
5	F	Rest	April - June 1	12.3 ± 0.6
6	G	Rest	Rest	10.6 ± 0.5
7	G-	Rest	Rest.	11.3 ± 0.7
8	G	Rest	Rest	15.6 ± 0.5
9	G-E	Rest	April 15 - June 1	14.2 ± 0.5
10	F+	May 15 - Oct. 15	Rest	14.9 ± 0.7
Sample 1				12.2 ± 0.2
Sample 2				12.8 ± 0.2
Combined				12.5 ± 0.2

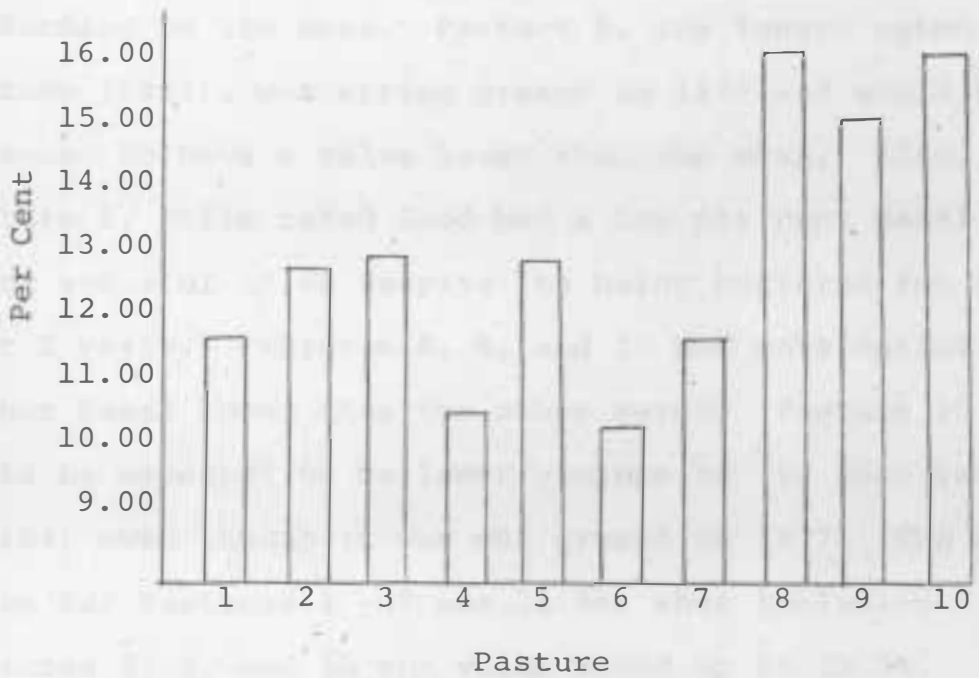

Figure 4. Per cent basal cover for the 10 sampled pastures of S. H. Ordway Memorial Prairie, 1977. Significance level of pasture differences = .05.

(Fair+) and summer grazed during 1977. Pastures 2, 3, and 5 approached the mean value of 12.5%. Pasture 2, rated low (Fair+) and spring grazed in 1977 would be expected to have a lower value. Pasture 3, rated (Good-) and rested in 1977, had the expected per cent basal cover conforming to the mean. Pasture 5, the lowest rated pasture (Fair), was spring grazed in 1977 and would be expected to have a value lower than the mean. Also, Pasture 6, while rated Good had a low per cent basal cover value of 10.6% despite its being ungrazed for the last 2 years. Pastures 8, 9, and 10 had substantially higher basal cover than the other seven. Pasture 10 would be expected to be lower because of its poor rating (Fair+) even though it was not grazed in 1977. The mean value for Pastures 1 - 7 was 11.5%; when including Pastures 8, 9, and 10 the value moved up to 12.5%.

Species Composition

Table 5 lists the 55 species found in quadrat sampling. The 47 species analyzed were selected on the basis of at least 20.0% frequency along one transect. Numbers less than that were too small to be analyzed. Analysis of variance provided the least-squares mean value of frequency by pasture. To facilitate pasture comparisons, only the 19 major species listed in Table 6 were included.

Table 5. Plant species found in quadrat and point frame sampling at S. H. Ordway Memorial Prairie, 1977.

Binomial Nomenclature	Common Name
Achillea millefolium L.	yarrow
Agropyron smithii Rydberg	western wheatgrass
Allium stellatum Ker-Gawler	pink wildonion
Ambrosia artemisiifolia L.	small ragweed
Amorpha canescens Pursh	leadplant
Andropogon gerardii Vitman	big bluestem
Andropogon scoparius Michaux	little bluestem
Anemone canadensis L.	meadow anemone
Anemone cylindrica A. Gray	thimble flower
Anemone patens L.	pasque flower
Artemisia frigida Willdorow	fringed sage
Artemisia ludoviciana Nuttall	louisiana sagewort
Aster ericoides L.	white aster
Astragalus adsurgens Pallas	prairie milkvetch
Bouteloua curtipendula (Michaux) Torrey	side-oats grama
Bouteloua gracilis (H.B.K.) Lagasca ex Steudel	blue grama
Bromus inermis Leysser	smooth brome
Bromus japanicus Thunberg	japanese brome

Table 5. Continued.

Binomial Nomenclature	Common Name
Buchloe dactyloides (Nuttall) Engelmann	buffalo grass
Calamovilfa longifolia (Hooker) Lamson-Scribner	prairie sandreed
Carex spp.	sedges
Cirsium flodmanii (Rydberg) Arthur	flodman thistle
Cirsium undulatum (Nuttall) Sprengel	wavyleaved thistle
Distichlis stricta (Torrey) Rydberg	saltgrass
Echinacea pallida Nuttall	purple coneflower
Helianthus maximiliana Schrader	maximilian's sunflower
Lactua pulchella (Pursh) DeCandolle	blue lettuce
Liatris punctata Hooker	dotted gayfeather
Linum rigidum Pursh	yellow flax
Lotus purshianus Clements and Clements	birdsfoot trefoil
Lygodesmia juncea (Pursh) D.Don	skeleton plant
Oxalis stricta L.	yellow woodsorrel
Oxytropis lambertii Pursh	purple locoweed
Panicum virgatum L.	switchgrass
Penstemon gracilis Nuttall	slender beardtongue
Petalostemum purpureum (Ventenat) Rydberg	purple prairieclover

Table 5. Continued.

Binomial Nomenclature	Common Name
Poa pratensis L.	kentucky bluegrass
Polygala alba Nuttall	white milkwort
Polygala verticillata L.	whorled milkwort
Polygonum convolvulus L.	black bindweed
Psoralea argophylla Pursh	silverleafed scurfpea
Ratibida columnifera (Nuttall) Wooton and Standley	coneflower
Rosa arkansana Porter	prairie rose
Rosa blanda Aiton	wild rose
Salsola kali L.	russian thistle
Solidago canadensis L.	canada goldenrod
Solidago missouriensis Nuttall	prairie goldenrod
Solidago mollis Bartling	soft goldenrod
Solidago rigida L.	rigid goldenrod
Sphaeralcea coccinea (Pursh) Rydberg	scarlet globemallow
Stipa comata Trinium and Ruprecht	needleandthread
Stipa spartea Trinius	porcupine grass
Stipa viridula Trinius	green needlegrass
Taraxacum laevigatum (willdenow) DeCandolle	redseeded dandelion
Thlaspi arvense L.	pennycress

Table 6. Binomial nomenclature, abbreviations, and common names of the species used in pasture comparisons (S. H. Ordway Memorial Prairie, 1977).

Abbreviation	Binomial Nomenclature	Common Name
Stco	Stipa comata	needleandthread
Stsp	Stipa spartea	porcupine grass
Agsm	Agropyron smithii	western wheatgrass
Popr	Poa pratensis	kentucky bluegrass
Dist	Distichlis stricta	saltgrass
Calo	Calamovilfa longifolia	prairie sandreed
Stvi	Stipa viridula	green needlegrass
Ansc	Andropogon scoparius	little bluestem
Ange	Andropogon gerardii	big bluestem
Bogr	Bouteloua gracilis	blue grama
Bocu	Bouteloua curtipendula	sideoats grama
Amar	Ambrosia artemisiifolia	small ragweed
Arlu	Artemisia ludoviciana	louisiana sagewort
Aser	Aster ericoides	white aster
Hema	Helianthus maximiliana	maximilian's sunflower
Soca	Solidago canadensis	canada goldenrod
Psar	Psoralea argophylla	silverleafed scurfpea
Lopu	Lotus purshianus	birdsfoot trefoil
Casp	Carex spp.	sedges

Table 7 shows the frequency percentage data for those species having a minimum value of 30.0% for at least one pasture. Carex spp. were the most widely dispersed species in all pastures except 2, 6, 7, and 8. Agropyron smithii was the most widely dispersed species in Pasture 2; Poa pratensis for Pasture 6, and Stipa viridula for Pastures 7 and 8. Stipa viridula, Agropyron smithii, Andropogon scoparius, and Carex spp. were common widely dispersed species among the 10 pastures.

Pasture 1 was distinguished by the dispersal of Stipa comata (31.1%), Poa pratensis (40.2%), and Helianthus maximiliana (34.5%).

Pasture 2 was distinguished by wide dispersal of Agropyron smithii (75.5%), and by a 31.5% level for Aster ericoides.

Pasture 3 was distinguished by a 32.8% dispersal value for Poa pratensis.

Pasture 4 had a relatively low value of dispersal for Agropyron smithii (32.8%) and had distinguishing values of 37.2% for Poa pratensis, 33.9% for Aster ericoides, and 39.4% for Artemisia ludoviciana.

Pasture 5 was characterized by the lack of Andropogon scoparius dispersal as well as values of 35.7% for Artemisia ludoviciana, 30.0% for Lotus purshianus, and

Table 7. Frequency Percentage of the More Common Species (S. H. Ordway Memorial Prairie, 1977).

	Grasses						
	Cool Season			Warm Season			
Pasture	Stco	Agsm	Popr	Calo	Stvi	Ansc	Bogr
1	31.1 ± 1.2	44.5 ± 1.1	40.2 ± 9.8	24.8 ± 1.2	56.4 ± 1.2	50.9 ± 1.2	20.2 ± 1.0
2	26.5 ± 1.7	75.5 ± 1.6	19.5 ± 14.5	9.0 ± 1.8	59.5 ± 1.8	44.5 ± 1.8	22.0 ± 1.5
3	27.2 ± 1.8	42.8 ± 1.6	32.8 ± 15.3	16.1 ± 1.9	61.1 ± 1.9	35.6 ± 1.9	20.0 ± 1.6
4	16.1 ± 1.8	32.2 ± 1.6	37.2 ± 15.3	10.6 ± 1.9	57.2 ± 1.9	31.1 ± 1.9	14.4 ± 1.6
5	22.1 ± 2.0	60.7 ± 1.9	63.6 ± 14.5	10.7 ± 1.8	53.6 ± 1.8	18.6 ± 1.8	20.0 ± 1.5
6	31.5 ± 1.7	49.5 ± 1.6	83.0 ± 14.5	21.0 ± 1.8	51.0 ± 1.8	48.0 ± 1.8	15.5 ± 1.5
7	41.0 ± 2.4	23.0 ± 2.2	2.0 ± 20.5	25.0 ± 2.6	75.0 ± 2.5	26.0 ± 2.6	3.0 ± 2.1
8	17.0 ± 1.7	36.5 ± 1.6	18.0 ± 14.5	31.5 ± 1.8	59.0 ± 1.8	51.0 ± 1.8	11.0 ± 1.5
9	9.6 ± 1.6	54.2 ± 1.4	23.8 ± 13.2	32.1 ± 1.7	37.5 ± 1.6	39.6 ± 1.7	45.4 ± 1.4
10	51.7 ± 2.2	34.2 ± 2.0	0.0 ± 0.0	52.5 ± 2.4	39.2 ± 2.3	29.2 ± 2.3	20.0 ± 1.9

Table 7. Continued.

Pasture	Others						
	Warm season				Cool season		
	Amar	Arlu	Aser	Hema	Psar	Lopu	Casp
1	25.2 ± 1.4	26.4 ± 1.3	20.7 ± 1.5	34.5 ± 1.2	6.6 ± 1.0	20.4 ± 1.0	72.5 ± 1.4
2	23.5 ± 2.1	23.0 ± 1.9	31.5 ± 2.2	6.0 ± 1.8	13.0 ± 1.5	23.0 ± 1.5	77.5 ± 2.2
3	26.7 ± 2.2	29.4 ± 2.0	29.4 ± 2.3	16.7 ± 1.9	14.4 ± 1.6	22.2 ± 1.6	73.9 ± 2.3
4	11.7 ± 2.2	39.4 ± 2.0	33.9 ± 2.3	23.9 ± 1.9	26.1 ± 1.6	11.7 ± 1.6	72.8 ± 2.3
5	14.3 ± 2.5	35.7 ± 2.2	25.0 ± 2.6	12.9 ± 2.1	30.7 ± 1.8	30.0 ± 1.8	74.3 ± 2.6
6	18.5 ± 2.1	23.5 ± 1.9	29.0 ± 2.2	14.0 ± 1.8	13.5 ± 1.5	7.5 ± 1.5	56.5 ± 2.2
7	13.0 ± 3.0	24.0 ± 2.7	26.0 ± 3.1	36.0 ± 2.5	14.0 ± 2.2	11.0 ± 2.2	48.0 ± 2.0
8	50.0 ± 2.1	28.5 ± 1.9	23.5 ± 2.2	17.5 ± 1.8	4.0 ± 1.5	7.0 ± 1.5	61.5 ± 2.2
9	42.5 ± 1.9	32.1 ± 1.7	29.6 ± 2.0	13.8 ± 1.6	8.3 ± 1.4	28.8 ± 1.4	67.9 ± 2.0
10	7.5 ± 2.7	13.3 ± 2.4	20.0 ± 2.8	16.7 ± 2.3	10.0 ± 2.0	30.0 ± 2.0	69.2 ± 2.8

30.7% for Psoralea argophylla. Pasture 5 was the only one with a 30.0% or higher dispersal figure for Psoralea argophylla.

Pasture 6 showed a dispersal of Stipa comata of 31.5% and the highest frequency value for Poa pratensis (83.0%).

Pasture 7 was characterized by Stipa comata dispersal (41.0%), Helianthus maximiliana dispersal (36.0%), and by the lowest dispersal value for Agropyron smithii (23.0%). Pasture 7 also had the highest value for Stipa viridula (75.0%).

Pasture 8 was characterized by a dispersal value of 50.0% for Ambrosia artemisiifolia and 31.5% for Calamovilfa longifolia.

Pasture 9 was the only one showing a frequency percentage value of 30.0% or more for Bouteloua gracilis (45.4%). It was also distinguished by levels of 32.1% for Artemisia ludoviciana, 42.5% for Ambrosia artemisiifolia, and 32.1% for Calamovilfa longifolia.

Pasture 10 showed the highest dispersal value for Stipa comata (51.7%) and a value under 30.0% (29.2%) for Andropogon scoparius. It was also distinguished by a 30.0% value for Lotus purshianus and a 52.5% value for Calamovilfa longifolia.

Relative density was calculated for those species amounting to at least 1 per cent of the population of at

least one pasture. These data are summarized in Table 8. Relative frequency values were calculated from Table 7 and the two sets of data were graphed by pasture (Figs. 5 - 14).

Pasture 1, rated Good, was dominated by the warm season grasses and by Carex spp. Andropogon scoparius was highest in number while Carex spp. were the most widely dispersed relative to the other species (Fig. 5).

Pasture 2, rated Fair+ was dominated by the warm season grasses. Andropogon scoparius was highest in number followed by Carex spp. Agropyron smithii was slightly lower than Carex spp. and was also the most widely dispersed (Fig. 6).

Pasture 3, rated Good-, had a more uniform mixture of cool and warm season grasses. Andropogon scoparius was highest in number while Carex spp. were the most widely dispersed. Stipa viridula and Carex spp. had very close values for relative frequency and relative density (Fig. 7).

Pasture 4, rated Fair+, was clearly dominated by Carex spp. both in number and distribution. The cool and warm season grasses are again fairly even, but the pasture was slightly more abundant with the warm season species (Fig. 8).

Pasture 5, rated Fair, showed the most uniform distribution among the warm and cool season grasses.

Table 8. Relative Density (Per Cent) of the More Common Species (S. H. Ordway Memorial Prairie, 1977).

	Grasses											Others							
	Cool Season				Warm Season							Warm Season					Cool Season		
Pasture	Stco	Stsp	Agsm	Popr	Dist	Calo	Stvi	Ansc	Ange	Bogr	Bocu	Amar	Arlu	Aser	Hema	Soca	Psar	Lopu	Casp
1.	4.7 ± 1.0	0.7 ± 0.4	3.5 ± 0.9	7.3 ± 1.6	0.5 ± 0.3	0.8 ± 0.4	16.7 ± 2.6	33.8 ± 3.7	6.8 ± 2.8	3.0 ± 0.9	1.9 ± 0.8	0.2 ± 0.2	0.0 ± 0.0	0.2 ± 0.2	0.9 ± 0.5	0.0 ± 0.0	0.2 ± 0.2	0.6 ± 0.4	15.7 ± 1.9
2.	6.2 ± 2.1	0.8 ± 0.6	13.8 ± 2.0	4.6 ± 1.7	0.0 ± 0.0	1.4 ± 1.1	12.4 ± 2.2	30.8 ± 5.1	3.1 ± 1.2	3.3 ± 1.2	0.4 ± 0.4	0.3 ± 0.4	0.4 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	16.1 ± 3.1
3.	6.3 ± 1.4	0.8 ± 0.8	5.8 ± 2.5	8.1 ± 2.1	0.0 ± 0.0	0.4 ± 0.4	17.3 ± 2.8	20.8 ± 5.0	5.9 ± 2.0	5.4 ± 2.0	0.4 ± 0.4	1.1 ± 1.1	0.4 ± 0.4	0.0 ± 0.0	0.4 ± 0.4	0.5 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	19.8 ± 2.3
4.	5.2 ± 1.5	0.9 ± 0.7	5.7 ± 2.7	9.7 ± 2.8	0.0 ± 0.0	1.7 ± 1.2	15.9 ± 3.9	13.1 ± 5.8	2.3 ± 0.9	2.8 ± 1.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	30.3 ± 5.2
5.	4.7 ± 1.7	2.0 ± 1.6	8.4 ± 2.8	21.9 ± 6.5	0.0 ± 0.0	1.0 ± 0.7	23.6 ± 5.2	9.1 ± 4.0	4.3 ± 2.1	4.5 ± 2.3	0.0 ± 0.0	0.4 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.5 ± 0.0	0.0 ± 0.0	0.4 ± 0.0	16.9 ± 3.0
6.	6.2 ± 2.0	0.8 ± 0.8	3.9 ± 1.3	11.8 ± 2.7	0.6 ± 0.6	0.8 ± 0.6	17.2 ± 2.7	28.2 ± 4.5	10.3 ± 3.1	1.6 ± 1.1	2.4 ± 1.6	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.2 ± 1.7
7.	7.7 ± 3.0	0.7 ± 0.7	4.5 ± 2.5	0.0 ± 0.0	1.1 ± 1.1	3.9 ± 2.2	29.0 ± 5.3	19.5 ± 4.3	1.1 ± 1.1	0.0 ± 0.0	0.7 ± 0.7	0.7 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	6.5 ± 3.7	0.0 ± 0.0	0.7 ± 0.7	0.0 ± 0.0	20.9 ± 6.0
8.	4.1 ± 1.0	0.8 ± 0.6	5.2 ± 1.4	10.4 ± 2.5	0.0 ± 0.0	6.1 ± 2.0	17.3 ± 3.0	27.6 ± 3.7	0.0 ± 0.0	2.2 ± 1.2	1.6 ± 0.9	1.0 ± 0.5	1.6 ± 1.6	0.4 ± 0.4	0.0 ± 0.0	0.4 ± 0.4	0.0 ± 0.0	0.0 ± 0.0	16.1 ± 2.0
9.	1.9 ± 1.2	0.5 ± 0.4	8.4 ± 1.4	4.4 ± 1.3	0.0 ± 0.0	4.9 ± 1.2	9.0 ± 1.8	21.7 ± 4.0	2.5 ± 1.6	15.8 ± 4.2	0.7 ± 0.4	0.5 ± 0.3	0.0 ± 0.7	0.3 ± 0.3	1.2 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	1.2 ± 0.7	17.5 ± 2.1
10.	12.2 ± 3.0	4.1 ± 1.5	3.3 ± 1.9	0.5 ± 0.5	0.0 ± 0.0	15.0 ± 3.7	14.8 ± 3.9	8.8 ± 1.9	2.6 ± 1.7	2.2 ± 1.2	2.2 ± 0.9	0.0 ± 0.0	0.6 ± 0.6	0.0 ± 0.0	0.5 ± 0.5	1.1 ± 0.7	0.0 ± 0.0	1.8 ± 1.3	20.2 ± 2.6

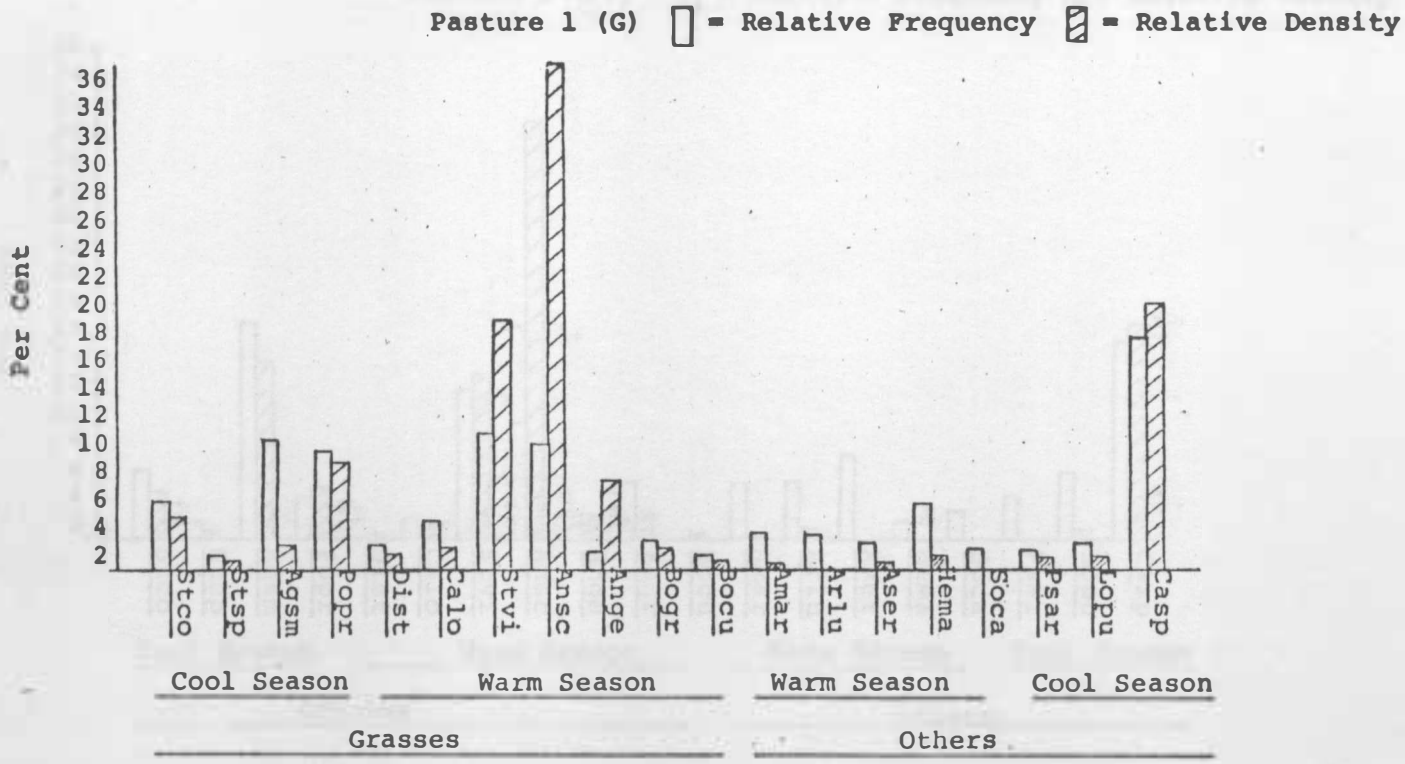

Figure 5. Relative density and relative frequency of common species in Pasture 1 of S. H. Ordway Memorial Prairie, 1977.

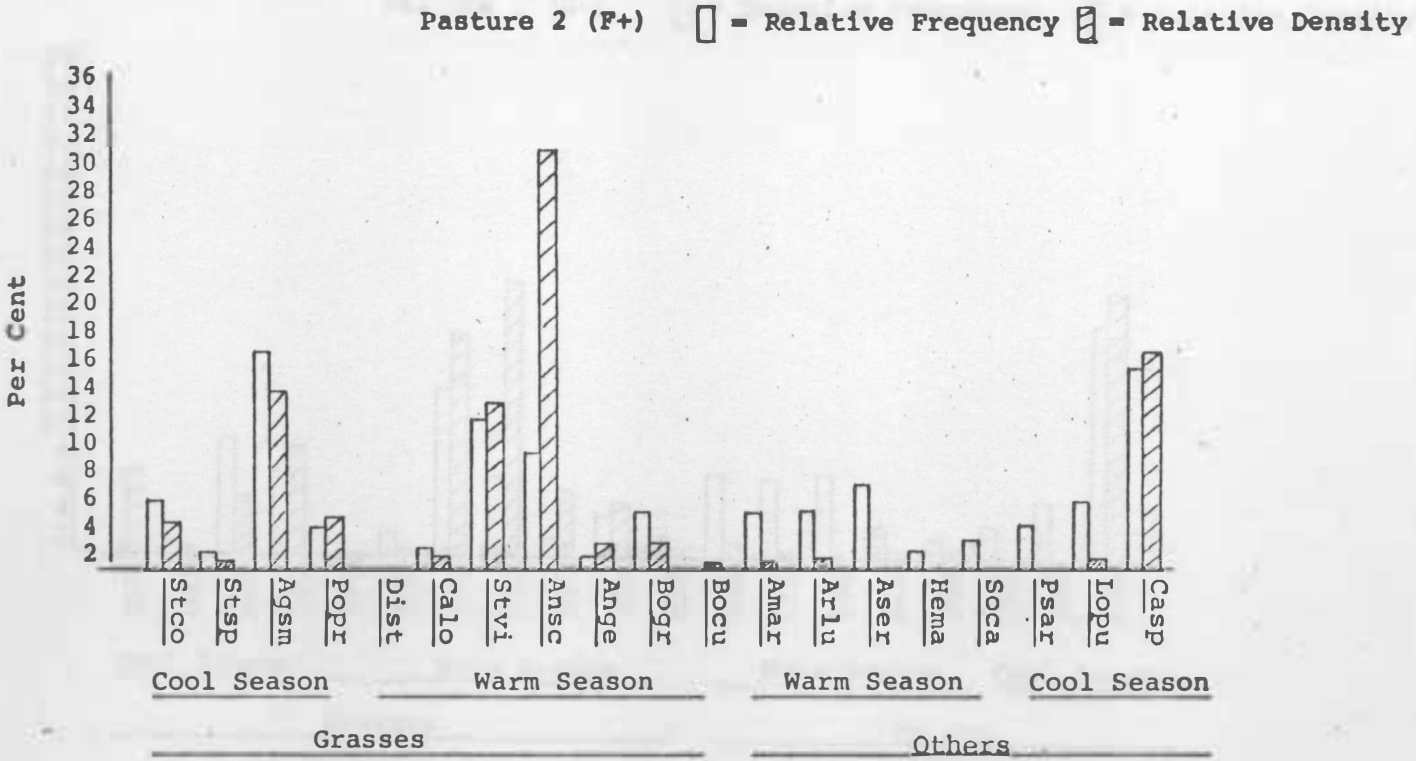

Figure 6. Relative density and relative frequency of common species in Pasture 2 of S. H. Ordway Memorial Prairie, 1977.

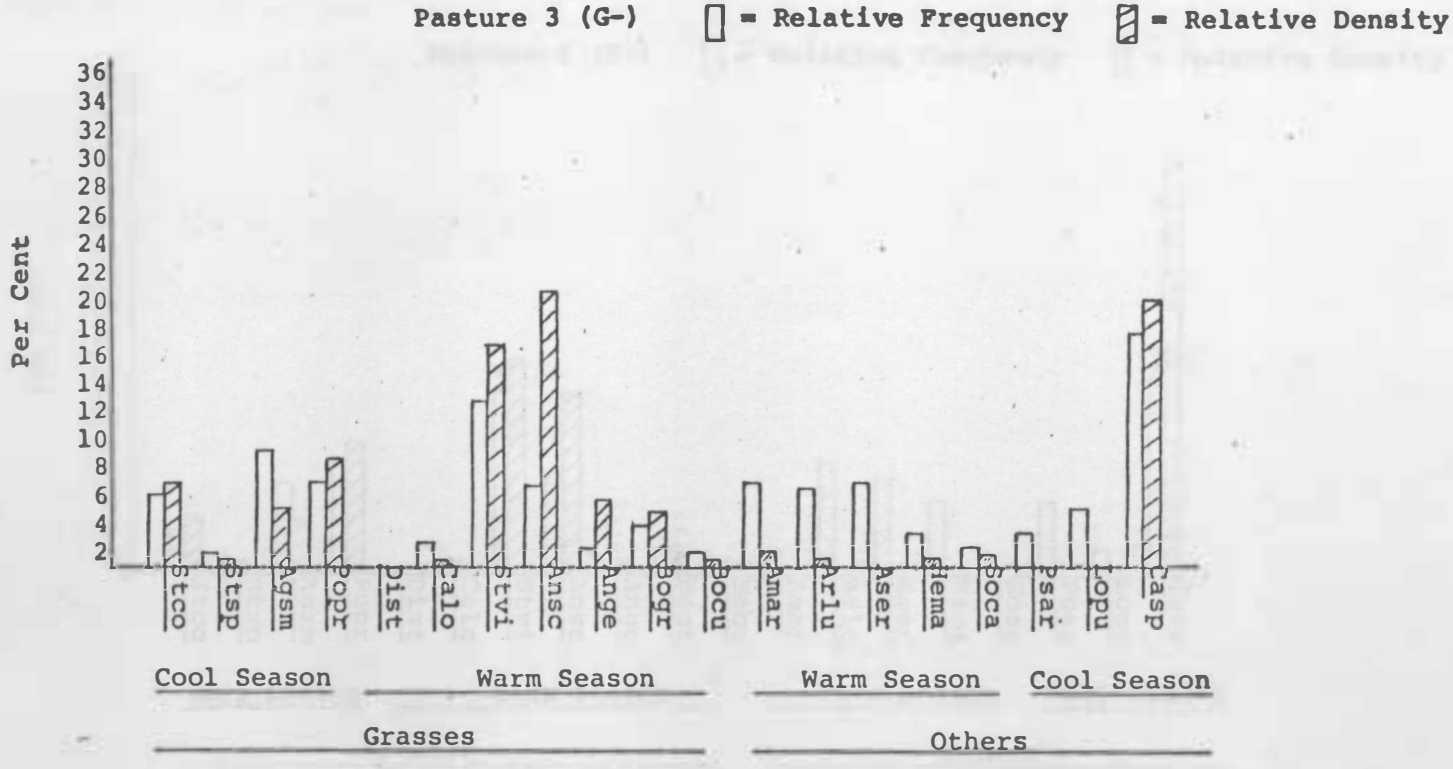

Figure 7. Relative density and relative frequency of common species in Pasture 3 of S. H. Ordway Memorial Prairie, 1977.

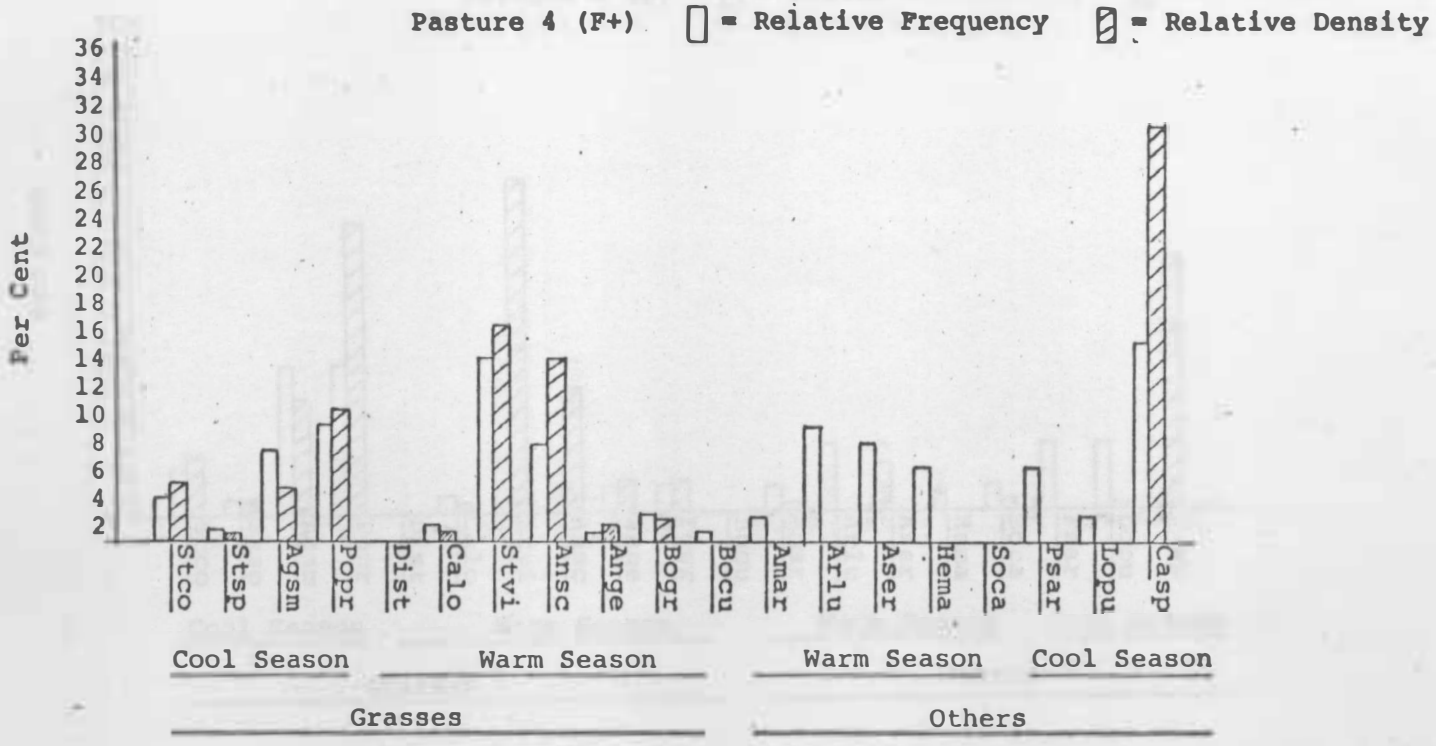

Figure 8. Relative density and relative frequency of common species in Pasture 4 of S. H. Ordway Memorial Prairie, 1977.

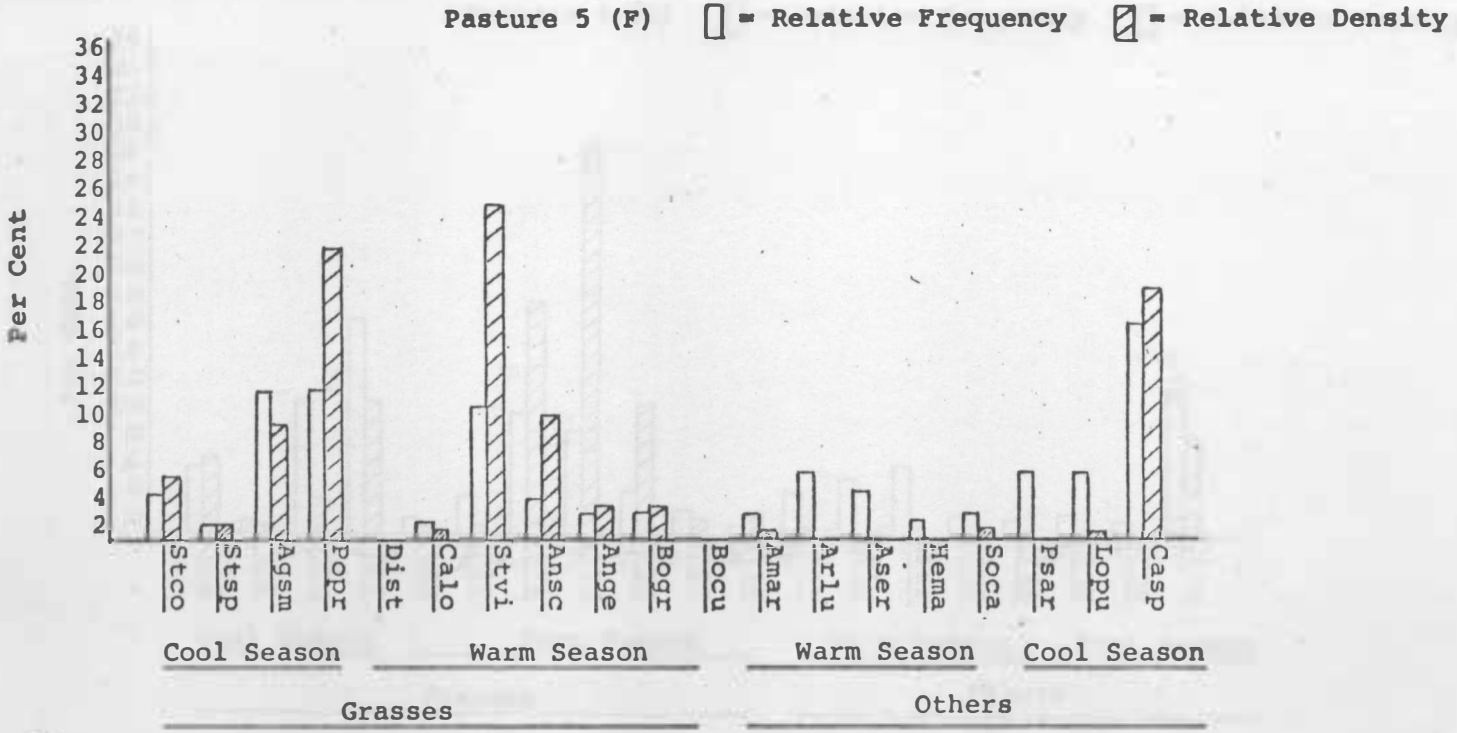

Figure 9. Relative density and relative frequency of common species in Pasture 5 of S. H. Ordway Memorial Prairie, 1977.

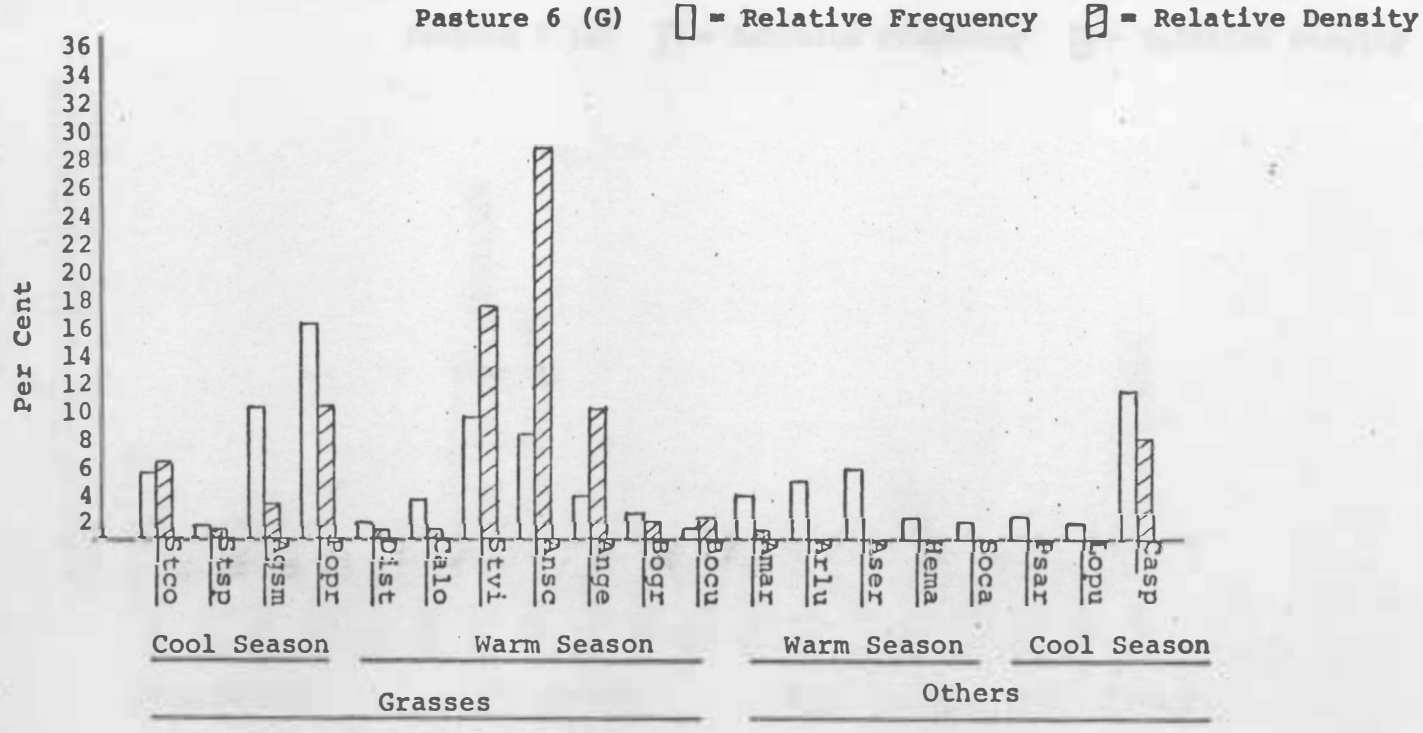

Figure 10. Relative density and relative frequency of common species in Pasture 6 of S. H. Ordway Memorial Prairie, 1977.

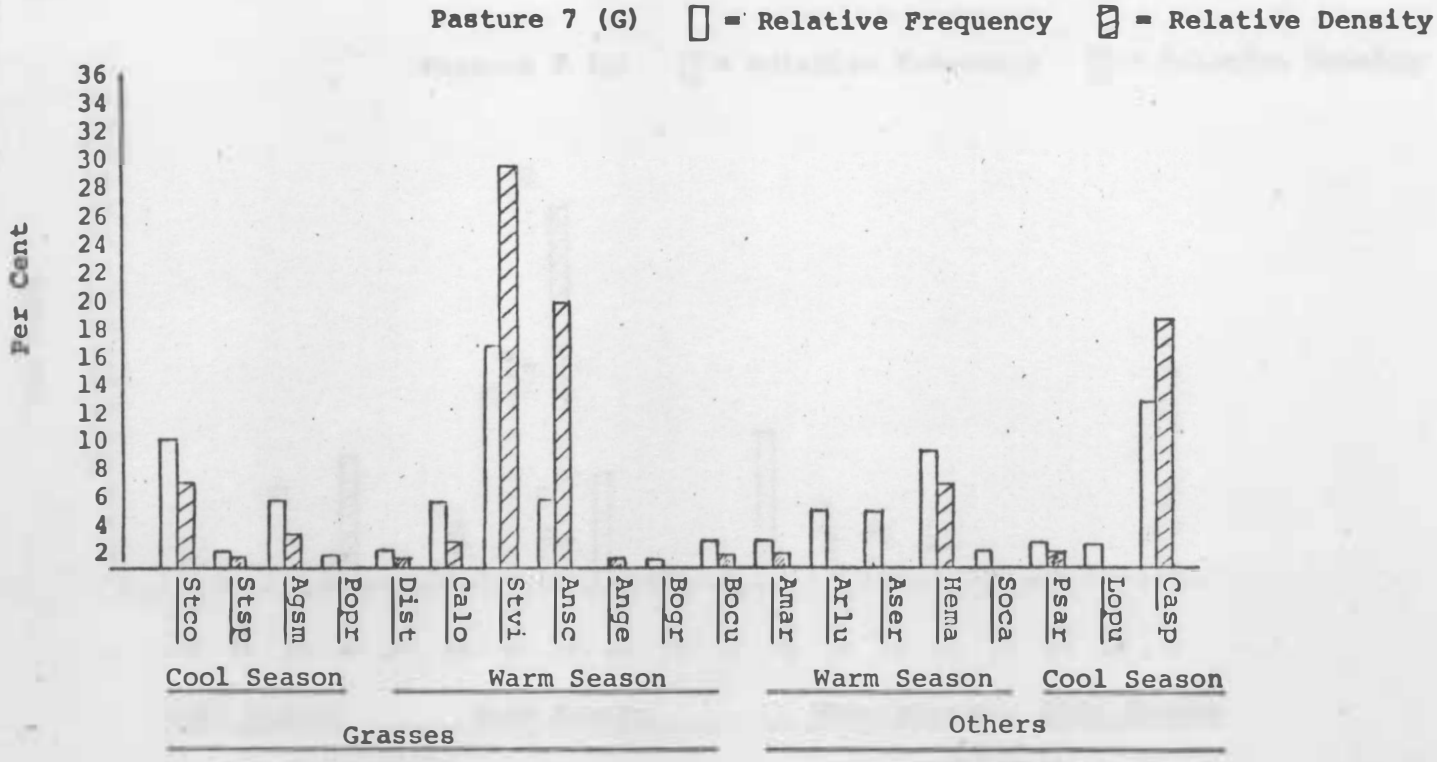

Figure 11. Relative density and relative frequency of common species in Pasture 7 of S. H. Ordway Memorial Prairie, 1977.

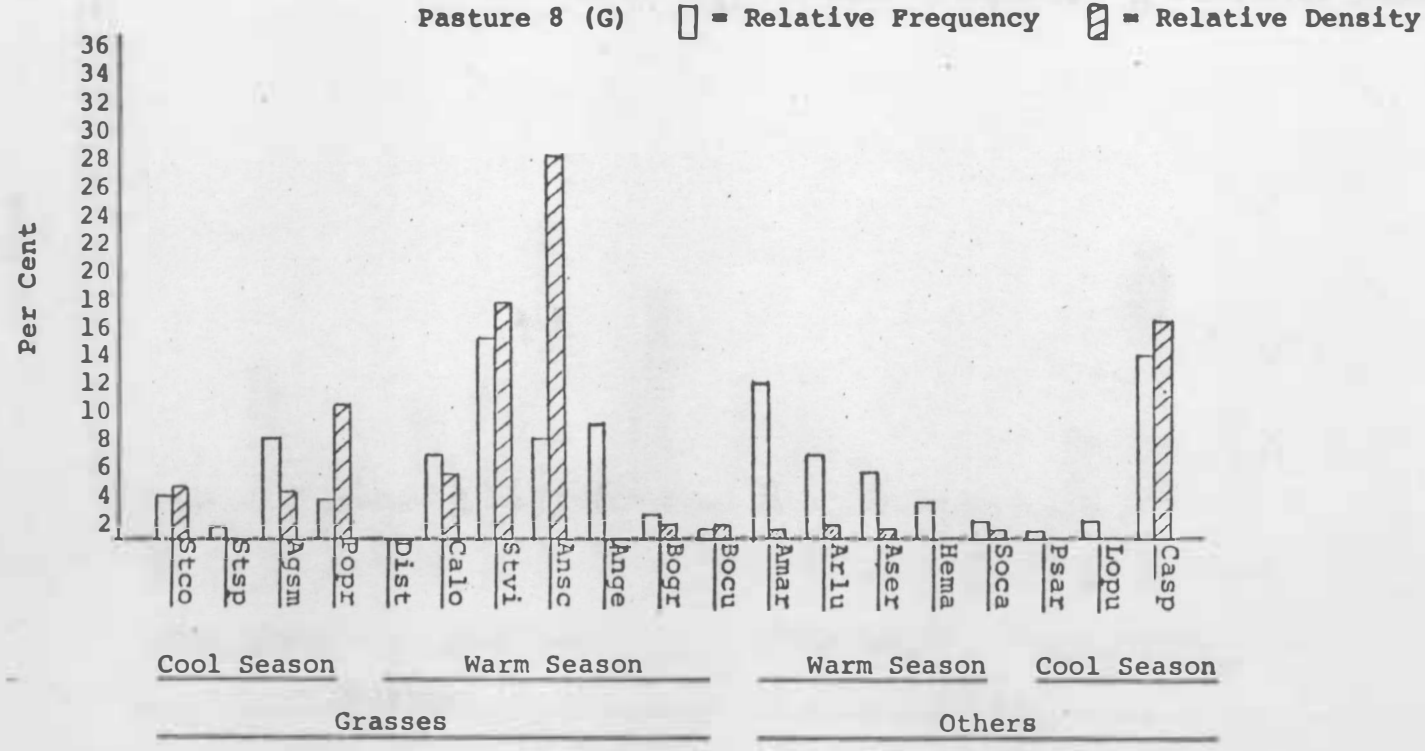

Figure 12. Relative density and relative frequency of common species in Pasture 8 of S. H. Ordway Memorial Prairie, 1977.

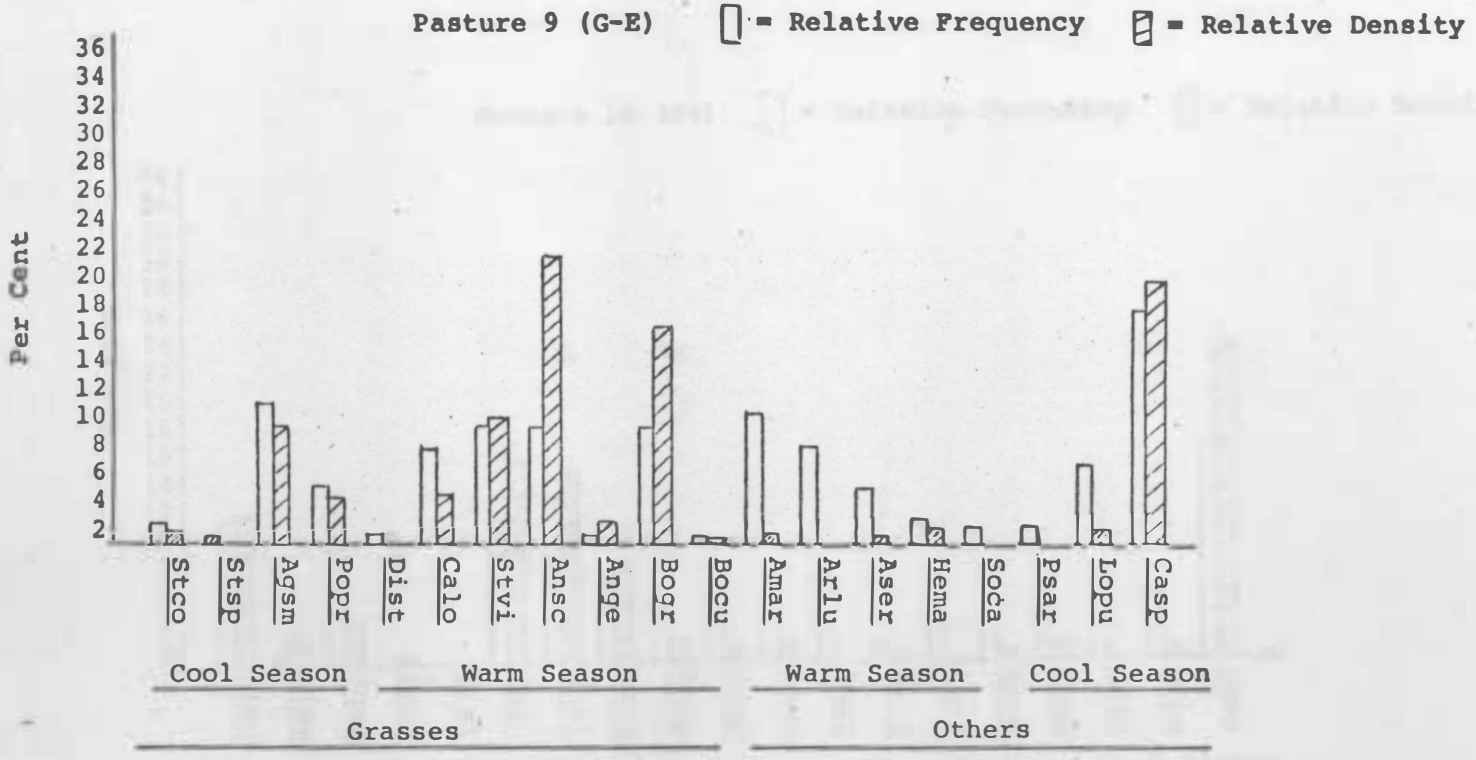

Figure 13. Relative density and relative frequency of common species in Pasture 9 of S. H. Ordway Memorial Prairie, 1977.

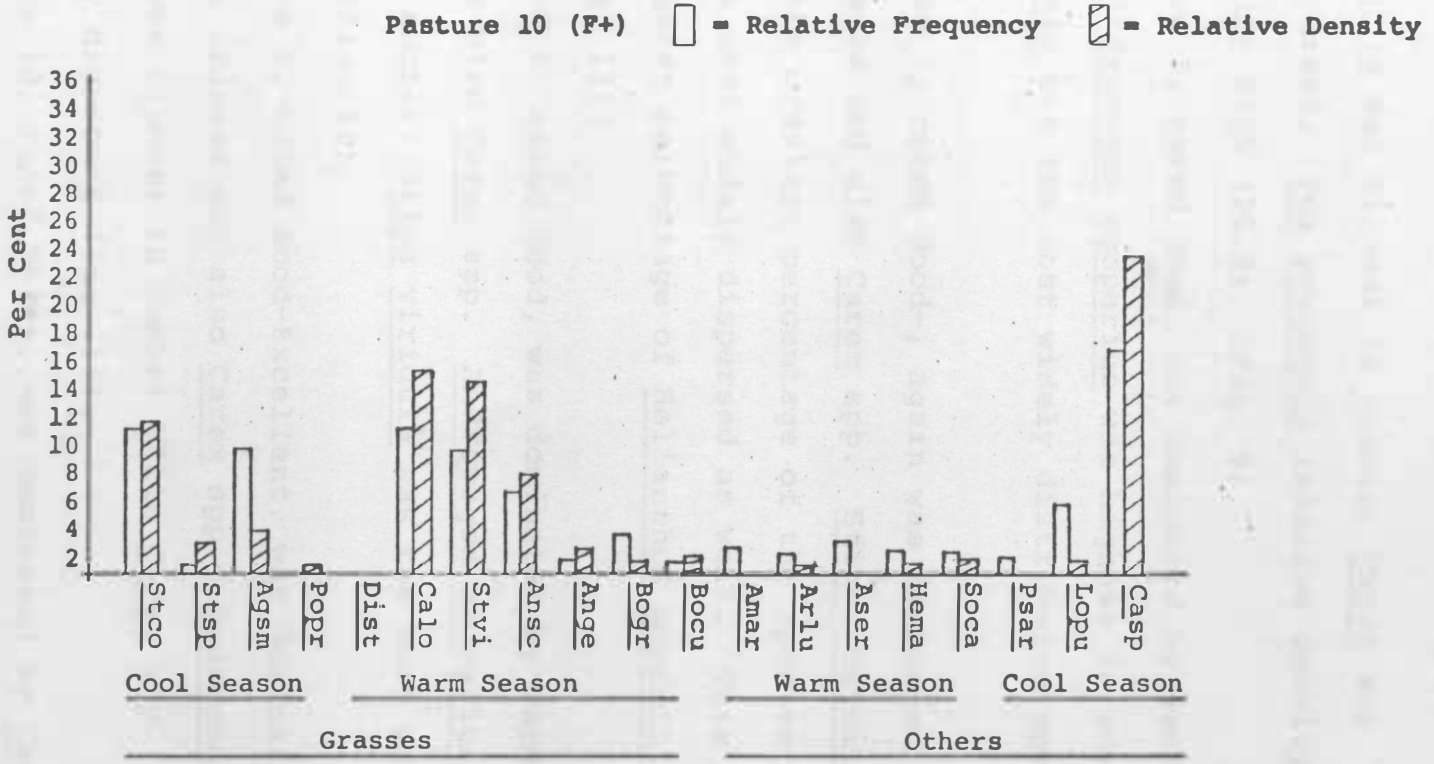

Figure 14. Relative density and relative frequency of common species in Pasture 10 of S. H. Ordway Memorial Prairie, 1977.

Stipa viridula was highest in number; Carex spp. were most widely dispersed. Poa pratensis relative density was exceptionally high (21.9%) (Fig. 9).

Pasture 6, rated Good, was dominated by warm season grasses. Andropogon scoparius was highest in number while Poa pratensis was the most widely distributed species (Fig. 10).

Pasture 7, rated Good-, again was dominated by warm season grasses and also Carex spp. Stipa viridula represented the greatest percentage of the species population and was the most widely dispersed as well. This pasture had the highest percentage of Helianthus maximiliana (6.5%) (Fig. 11).

Pasture 8, rated Good, was dominated by warm season grasses and also Carex spp. Andropogon scoparius was highest in number; Stipa viridula was the most widely dispersed (Fig. 12).

Pasture 9, rated Good-Excellent, was dominated by the warm season grasses and also Carex spp. Andropogon scoparius was highest in number while Carex spp. were the most widely dispersed (Fig. 13).

Pasture 10, rated Fair+, was dominated by Carex spp. and the warm season grasses. Carex spp. were the highest in number and were the most distributed. An exceptionally high density value for Stipa comata (12.2%) was shown

and also for Calamovilfa longifolia (15.0%) (Fig. 14).

All pastures at Ordway Prairie appeared to be dominated by warm season species, with Pastures 3, 4, and 5 having the closest to an even distribution.

The relative density data from Table 8 were used to calculate community similarity coefficients. This gave a mathematical expression of the degree of similarity of two communities. The procedure is outlined in Cox (1967). This provided a quantitative representation of the degree of similarity (in terms of relative density) of the 45 possible pasture comparisons (Fig. 15). Each pasture can be compared to any other to determine similarity of species composition. A coefficient of 0.85 is usually considered as identical (Cox 1967). The values in Figure 15 are, therefore, unusually high, indicating the pastures at Ordway Prairie do not differ a great deal in terms of species composition. Figure 16 shows the ranking of the 45 pasture comparisons. The two pastures which were most similar were 1 and 6, both rated Good. The two most dissimilar pastures were 6 and 10 (6 is rated Good; 10 is rated Fair+). According to the pre-rated pasture conditions, Pastures 5 (Fair) and 9 (Good-Excellent) would be expected to show up as the most dissimilar. The similarity coefficient for these two pastures was .65.

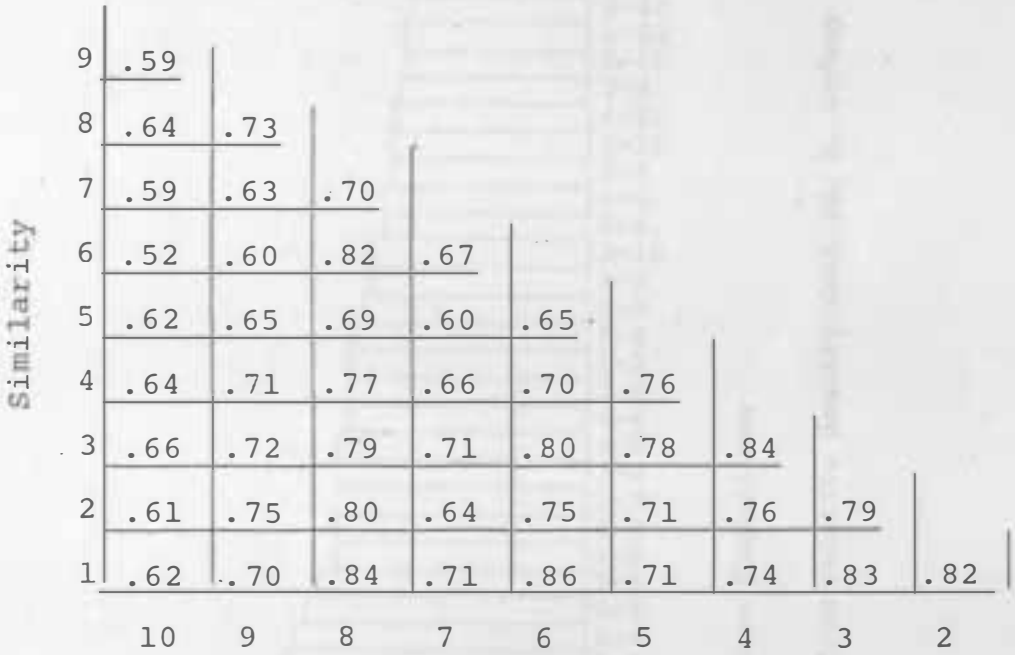

Figure 15. Similarity coefficients between pastures (S. H. Ordway Memorial Prairie, 1977).

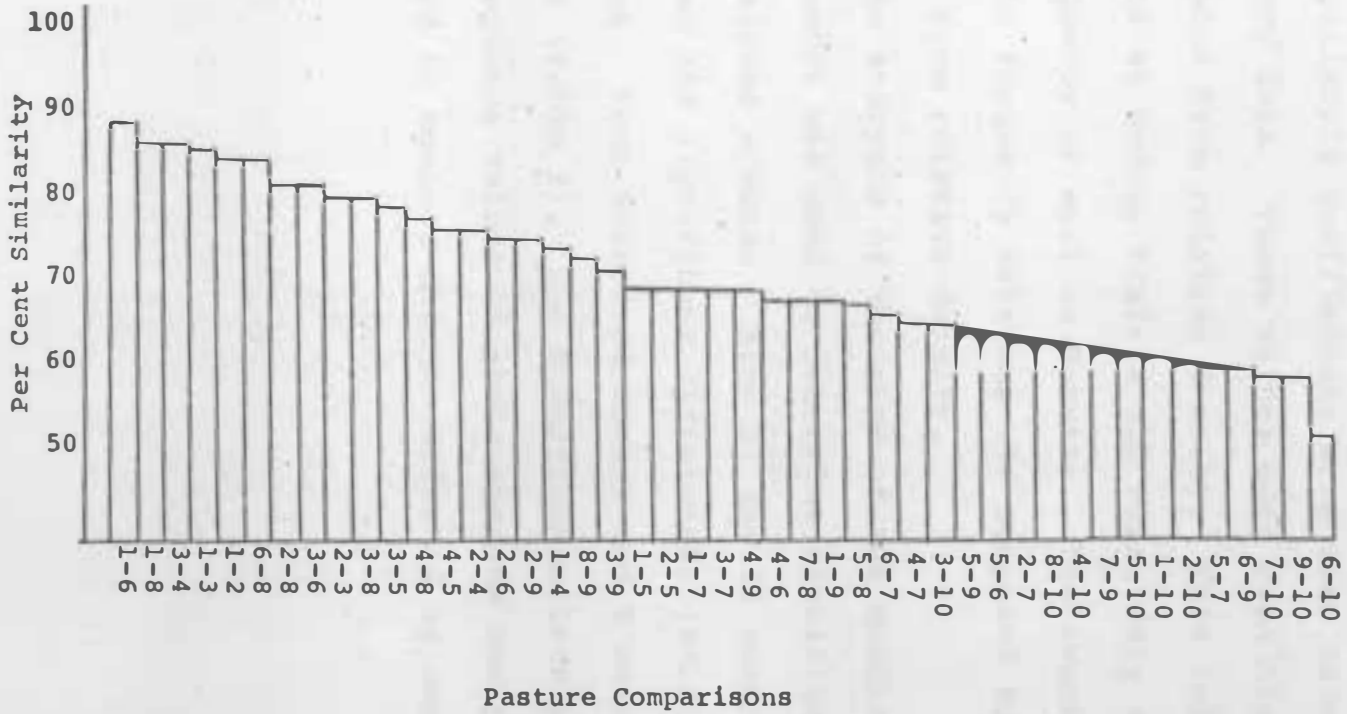

Figure 16. Similarity of pastures calculated from relative density data (S. H. Ordway Memorial Prairie, 1977).

Similarity coefficients were also calculated from the frequency data. These values were even higher than those calculated from relative density. This indicates that the pastures at Ordway Prairie are relatively similar in terms of frequency as well as density. The average similarity from the frequency data was .76 compared to an average of .71 from relative density.

The analysis of variance of the quadrat data (frequency) was used to determine significance levels of the analyzed species. Nine of the 19 species extensively examined had significant differences ($P<.05$) between pastures. Four were cool season and 5 were warm season species (Table 9). The significance levels indicate that the frequency values of these species can provide a valid standard to measure changes affected by management practices.

Table 9. Species Significance Levels. Those that show significance levels indicate differences in distribution among the 10 pastures (S. H. Ordway Memorial Prairie, 1977).

Species	Significance Levels			
	.05	.025	.01	.005
Stipa comata			X	
Stipa spartea				
Agropyron smithii		X		
Poa pratensis	X			
Distichlis stricta				
Calamovilfa longifolia				X
Stipa viridula	X			
Andropogon scoparius				
Andropogon gerardii				
Bouteloua gracilis				X
Bouteloua curtipendula				
Ambrosia artemisiifolia				X
Artemisia ludoviciana				
Aster ericoides				
Helianthus maximiliana		X		
Solidago canadensis				
Psoralea argophylla				X
Lotus purshianus				
Carex spp.				

SUMMARY AND CONCLUSIONS

Live weight biomass at Ordway Prairie was found to average 133.3 $g \cdot m^{-2}$; mulch was found to average 104.0 $g \cdot m^{-2}$. The highest amount of live weight biomass was found in Pasture 3 (171.0 $g \cdot m^{-2}$); the lowest in Pasture 9 (103.2 $g \cdot m^{-2}$). The highest amount of mulch was found in Pasture 2 (154.9 $g \cdot m^{-2}$); the lowest in Pasture 5 (38.8 $g \cdot m^{-2}$).

Basal cover for the study area was found to average 12.5%. Pasture 8 showed the highest amount (15.6%); Pasture 6 showed the lowest (10.6%).

The Ordway Prairie is predominantly composed of warm season species. Pastures 3, 4, and especially 5 emerge as the ones with a more uniform distribution of cool and warm season plants.

Andropogon scoparius was the most abundant species in Pastures 1, 2, 3, 6, 8, and 9. Carex was highest in number for Pastures 4 and 10. For Pastures 5 and 7, Stipa viridula was highest in number.

Carex was the most widely dispersed group for Pastures 1, 3, 4, 5, 9, and 10. In Pastures 7 and 8, Stipa viridula was the most widely dispersed species. In Pasture 2 the most dispersed was Agropyron smithii; in Pasture 6, Poa pratensis.

Nine of the 19 species extensively examined had significance levels of .05 or less when tested for significance of differences between pastures. These species together with the biomass, basal cover, and species composition data, can provide a valid standard to measure changes affected by management.

The data suggests a variety of management practices. Spring grazing can be used to favor warm species; late summer grazing can be used to favor cool species. The data in Figure 15 provides information which can be used to determine which grazing management would be preferred.

Some of the pre-rated pasture conditions do not entirely coincide with the data of this study. Specifically, they are those given for Pastures 2, 5, 6, 9, and 10. However, the study area appears to be more congruous than originally believed. The data from the second year of this project should be compared to these findings to arrive at final pasture ratings.

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